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ABSTRACT

The use of computer assisted instruction in teaching statistical concepts was studied. Students enrolled in classes in education who lacked statistical experience participated. Knowledge questions for pretest and posttest assessments were prepared from a pool of questions used in the statistics department of the College of Education at Virginia Tech. Software modules for this pilot study were created through computer software applications and implemented in a Windows 3.1 environment. Central limit theory was the concept presented, and it was presented in one of three different computer-mediated ways: (1) text, graphics, plus static interaction (TGS); (2) text, graphics, plus animated interaction (TGA); and (3) text, graphics, plus passive video (TGPV). Because the investigation was a pilot study to support further investigation, analyses were not developed in depth. Gains in knowledge were found, however. Participants were less enthusiastic about TGS than the other presentations, with TGA appealing to most. Issues for further study are discussed. (Contains 16 references.) (SLD)

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A Comparison of Three Presentation Methods of Teaching Statistics

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Most graduate students enrolled in doctoral programs in education must complete a course in statistics to obtain a degree. Yet, few students report having understood the connection between studying statistics and successfully completing their programs, much less the role it might play in advancing their careers after graduation. As a result, taking "stat" courses is often delayed until the latter portion of the doctoral program often serving as the last hurdle students need to clear.

In view of this observation, it is appropriate to look for ways to reduce anxiety and fears associated with the study of statistics and to discover how the subject can be made more relevant to the learning process, as well as, post-graduate professional practice. One such possibility resides in the use of computers as an aid to the delivery of instruction.

Whereas many educators may agree on the potential offered by computers to facilitate instruction, some question their utility. This is evidenced in research which suggests that computers may induce learning anxiety, rather than alleviate it (Farina, et al., 1991; Kinzie, et al., 1991; Rosen & Weil, 1990; Ladany, 1991; Dambrot, et al., 1985; Collis, et al., 1989). However, several researchers have suggested that this problem can be addressed in a simple, straight forward manner. That is, by targeting computer illiteracy, students can be trained to overcome their fears with regard to the use of computers (Rivizzigno, 1980; Nickerson, 1981; and Rubin,1983).

Computers have been envisioned as a medium through which to achieve distance learning efficiently, remediate learners, provide advanced placement opportunities, and supplement the regular instructional program (O'Hara & Patton, 1992; Mays & Lumsden, 1989). Furthermore, computers (e.g., interactive multimedia) may benefit students by empowering them to choose how they learn. Students become more independent while extending their normal thought and building confidence as self-directed learners.

Visual spatial abilities of learners should be considered when using computers to deliver instruction. Computer assisted learning environments "provide visuospatial

organization (opportunities) for the user". Consequently, as suggested by Ruff et al., (1992), lower visuospatial students (i.e., those with lesser ability to conceptualize visually) will perform better when learning via the computer. This is because computers allow the easy visual manipulation of variables which increases students' understanding of the relationships between them. An interesting parallel exists between this phenomenon in general, and how students learn statistics. That is, teaching methods used in statistics courses often employ visually oriented techniques (Ben-Chaim et al., 1989; Bishop, 1989; Hershkowitz, 1989). Thus, it would seem natural that a marriage be formed between this computerized media and other methodologies to deliver instruction in statistics.

This preliminary investigation provided opportunities to explore several issues (e.g., choice of medium, screen design, use of feedback, interaction strategies, etc.) which surround the development of computer mediated instruction designed to facilitate the learning of three fundamental statistical concepts - central limit theory, hypothesis testing, and differences between sample populations (t-test). A Brunswikian approach served as a model for developing the design by providing ways to alter the use of time, learning pace, and methodology.

The Brunswikian approach assumes that individuals learn by interacting with their environment to seek distal goals. The interaction occurs by the individual choosing cues that lead toward the goal, interacting with the cues, gaining feedback, and then choosing another cue. This sequence allows the individual to pace the project, to seek preferences in the choice of cues, and to control the learning process.

For each content objective a minimum of five Brunswikian instructional strategies were considered: simulation, workbook, programmed instruction, guided reading, and taped lectures. However, only three of the five were modified for delivery via a multimedia environment and piloted for this study; that is, simulation (text, graphics, and animated interaction) programmed instruction (text, graphics, and non-animated

interactions) and taped lecture (text, video vignettes, and no interaction.). Students were able to select one or more of these to master a selected objective.

Several hypotheses were formulated with the expectation of results from the pilot lending support to their validity and justification for use in subsequent investigations. First, it was hypothesized that individuals who participated would demonstrate a preference for instructional methodology, along with a resulting improvement in their statistical knowledge. Second, participants with low-visual spatial skills were predicted to benefit greater, by comparison, to those with high visual-spatial skills. Finally, it was hypothesized that the quality of interaction (animated vs. static) would be a factor in determining the extent to which participants would learn statistical concepts.

Methods

Participants. All participants were drawn from a population of students enrolled in educational classes at Virginia Tech. Students were selected because of their apparent lack of comprehensive statistical experience. They were given an explanation of the purpose of this experiment as being related to computer mediated learning. It was further explained that statistics was chosen as the content because of the difficulty perceived by students who were required to complete the course in their programs of study.

Pre and Post test measures. Knowledge questions for both pre-test and post-test assessment were extracted from a pool of questions used in the College of Education's statistics department. These questions are normally used to test knowledge of statistical concepts among students who wish to further advance their study in graduate level courses. A total of twenty-four questions were chosen to reflect the material presented during the computer mediated instruction. A computer attitude scale developed by Hergert & Holmes (1993) was used to test participants' attitudes toward using the

computer and its relevancy in education. Finally, spatial relations were assessed by the Mental Rotation Test developed by Vandenberg & Kuse, 1978).

Computer software. Software modules used as interventions throughout the pilot study were created with the help of three computer software applications: *Authorware* (Macromedia, Inc.), *Turbo C++*, (Borland International, Inc.) and *Video for Windows* (Microsoft Corporation). All programs were implemented in a Windows 3.1 (Microsoft, Inc.) environment while running on an Intel 80486 (8Mb RAM) platform.

Procedure

Assessment. Students were assessed prior to, and immediately following intervention to determine the extent to which knowledge and/or attitudes might have been influenced by each of the treatments. Visuospatial aptitude was assessed according to guidelines specified in the Mental Rotation Test (MRT). The test was administered in two parts and timed. Participants were allotted three minutes to complete each section.

Treatments. Of the three statistical concepts (central limit theory, hypothesis testing, and comparison of sample means or t-test) which may have been chosen as the content for this pilot investigation, central limit theory was randomly selected. Subsequently, relevant content was introduced to Participants in one of three different, computer-mediated ways: text, graphics, plus static interaction (TGS); text, graphics, plus animated interaction (TGA); and text, graphics, plus passive video (TGPV).

Participants in the TGS group were asked to read passages pertaining to content and manually move either forward or backwards throughout the program (one page at a time) until completing the exercise. At designated locations, participants were given the opportunity to further interact with the program by responding to several multiple choice questions designed to test comprehension. Questions were presented with participants responding via the click of a "mouse." Knowledge-of-response feedback was also generated by the computer.

Participants in the TGA group viewed the same text and graphics, plus navigated through the program in an identical fashion to those students in the TGS group. However, the interactions which tested comprehension were different in that they included an animated graphic visual component to visually reinforce their understanding of central limit theory concepts. That is, participants were asked to complete a table of points (See Appendix 1) which were immediately plotted by the computer program. Repeated trials were optionally available depending on the participant's perceived mastery of the concept.

Participants in the TGPV group passively viewed video vignettes which included an actor reading aloud the same text and graphics presented on the screen in each of the previous groups. The computer automatically advanced the graphic display embedded in the program and thus, altogether eliminated any control or interruption on the part of the user.

Results/Discussion

The purpose of this pilot study was to gather evidence which might support further investigation in the use of computers to teach statistics. It was not to establish statistical significance nor provide descriptive data for qualitative purposes per se. Consequently, analyses were not developed in depth. Whereas qualitative data was considered as more important, quantitative findings remained a secondary issue. Positive gains in knowledge was treated merely as indicators for continuation of this project. It might be interesting to note, however, that preliminary t-tests to observe any knowledge gain were found with a significant t of 3.90, $p = .0023$.

Results of interviews conducted with participants provided useful information for possible follow-up investigations. Comments on the text, graphic, and static interaction (TGS) module were less enthusiastic than other presentations. It "was not too different

from reading a book" was a typical statement. The possibility of being distracted in the test situation sitting side by side at computer terminals bothered a few students who gave statements such as, it was "too easy for me to look at others and feel pressed". The text, graphic, animated interaction (TGA) module held most of the participants captive with comments such as the following: "helps to see visually"; "examples help me to process and better understand"; and "why didn't you have something like this when I needed it?".

Creating different modules which promote learning, accommodating varying learning styles, and making them available through the regular term would increase the opportunity for students to gain the understanding of concepts important within their course of study. By setting in place modules such as the ones described above will allows students to set their own time, pace and method to better understand statistical concept(s).

This proposed model is based on a range of potential learning experiences or cues, giving the students ample opportunity to practice their new skills and knowledge. It also addresses the concerns of students who feel that there is too little opportunity to practice or apply the results of their classroom instruction. Since this approach would give multiple ways to acquire statistical skills and knowledge, students are better assured that the understanding of concepts is not dependent on the context of the classroom or a set style of delivery. Students may spend as much time as they desire in any of the environments defined by content groupings of objectives; hence, for those students who attribute their problems on vicarious exposure to the most basic concepts, more study time is available for the internalization of the knowledge.

With the results of this pilot study, individual differences will be approached. Further research questions include: How does the position of the text and graphic display affect the learner? What effect does the color and the background have on the learner? Does freedom of movement allow the student to feel more in control of their learning?

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